Description

Blade and gas turbine

The invention relates to a blade for use in turbomachines, having a blade root, a platform region and a main blade part, which main blade part has a blade length from a blade leading edge to a blade trailing edge and a blade height from the platform region to a main blade part tip, and which is formed from at least one base body segment and, in the region of at least one of the two blade edges, from at least one edge segment which is connected in a positively locking manner to the base body segment.

A corresponding turbine blade of modular construction is known from US 4,786,234. The main blade part disclosed in that document is composed of a plurality of components or segments. In this case, the different segments are divided over the blade height. In a variant, US 4,786,234 shows a main blade part which is divided in the direction of the blade length, with in particular the leading edge and the trailing edge of the main blade part being designed as separate, radially movable components.

To apply, for example, the latter embodiment of US 4,786,234 to a guide vane with a base body segment and two cast-on platforms, at least one of the two platforms must have an opening through which the radially displaceable blade edge can be pushed onto the main blade part. In this case, special design measures, such as for example sealing measures in the transition region between main blade part and platform, are required, and these measures are disadvantageous for production and operation.

The invention is therefore based on the object of providing an alternative, simplified design of a modular blade while at the same time increasing the service life. A further object of the invention is to provide a turbomachine with reduced maintenance and production costs.

The object relating to the blade is achieved by the features of claim 1, and the second object is achieved by the features of claim 14. Advantageous configurations are given in the subclaims.

As a solution, it is proposed that the positively locking connection is produced by means of projections which are formed integrally on one of the segments and are spaced apart from one another in the direction of the blade height, with the other segment at least partially arranged projecting in between the projections.

This connection allows particularly simple fitting of the blade trailing edge and/or the blade leading edge, since the edge segments are formed such that they can be displaced transversely with respect to the blade edge. Therefore, with the blade according to the invention, the edge segment can be exchanged without having to dismantle the blade, which shortens the repair time. Furthermore, the modular structure allows the blade edges of the main blade part, which are subject to higher stresses and are accordingly more vulnerable, to be selectively exchanged. This increases the service life of the base body segment, which is subject to less wear. Furthermore, the exchangeable regions can be deliberately matched to the mechanical and thermal demands, which leads to cost savings.

Furthermore, the segmentation allows production of standard segments for the individual blade sizes, with the result that, based on use and wear, the costs

can be reduced further by standardization. It is in this context advantageous if the segments have different dimensions, so that the regions of the individual wear levels can be optimally combined. The connection can be effected by a press fit, soldering, welding, adhesive bonding or pinned connections. In this context, it is advantageous for the segment connecting surfaces to be oriented horizontally and/or vertically.

In an advantageous configuration, a particularly effective connection can be achieved if the base body segment and the edge segment each have a plurality of projections with recesses between them. Then, the projections arranged on one of the two segments can project in a positively locking manner into the opposite recesses in the other segment, forming positively locking toothing. This allows secure attachment of the blade edges in particular in the case of rotor blades, since the centrifugal forces acting on the edge segments in the radial direction during operation can be compensated for by a segment connecting surface of the base body segment running transversely with respect thereto.

According to a particularly advantageous configuration, a holding pin which runs in the direction of the blade edge secures the segments against relative movements by virtue of this holding pin penetrating transversely through the projections of both segments. The toothed arrangement of the projections results in overlapping, intermeshing regions through which an aligned bore, in which the holding pin is fitted, can extend.

A further advantageous configuration provides for the segments which form the main blade part to be made from different materials. This is advantageous since there are regions which are subject to higher mechanical stress and regions which are subject to higher thermal stresses, with the result that

the main blade part can be optimally matched in its segmented structure to the individual wear conditions by virtue of the different materials. According to further teaching of the invention, some of the segments may be made from a particularly thermally conductive material, and others may be made from a material which is resistant to high temperatures.

Suitable materials in this context are ceramic material, metals, metal alloys and plastics materials. In addition, further teaching of the invention provides for the segments to be coated. This allows the properties of the segments to be deliberately influenced further.

To reduce weight, the segments may have cavities. These cavities may in this case be filled with a material which is different from the segment material. This material may, for example, be foams. It is in this way possible to deliberately influence strength properties of the segments.

It is expedient for the blade to be designed as a guide vane or as a rotor blade. It is particularly advantageous for a blade of this type to be used in a gas turbine.

Further features and advantages of the invention will emerge from the following description of the associated drawing, which diagrammatically depicts an exemplary embodiment of a modular blade edge of a main blade part for a turbomachine. In the drawing:

Fig. 1 shows a perspective view of a blade according to the invention with a trailing edge segment,

Fig. 2 diagrammatically depicts a partial sectional view of a blade according to the invention with a trailing edge segment;

Fig. 3 shows a diagrammatic side view of a blade with an alternative trailing edge segment,

Fig. 4 shows a perspective view of a blade according to the invention with a leading edge segment, and

Fig. 5 shows a diagrammatic partial sectional view of a blade according to the invention with a leading edge segment.

Turbomachines use blade stages, which comprise adjacent rotor blades and guide vanes, to convert flow energy into rotary energy and vice versa. The guide vanes are arranged on the machine housing, while the rotor blades are directly connected to the rotor.

A blade 1 according to the invention with a segmented trailing edge is illustrated in figs. 1 to 3. The blade 1 itself has a platform 2a and a main blade part 3 with a blade leading edge 4 and a blade trailing edge 5. A second platform 2b, which is formed integrally at the upper end 5a of the main blade part 3, is illustrated by dashed lines. The main blade part 3 is composed of a base body segment 3b and a trailing edge segment 3c. As can be seen at the upper end 5a of the main blade part 3, the base body segment 3b has a plurality of cavities 6 which, given sufficient strength, are used to reduce the blade mass in order to lower the mechanical and thermal stresses in operation. One or more cavities 6 may be filled with a foam in order to increase the strength of the main blade part 3.

In the region of the blade trailing edge 5, the trailing edge segment 3c has projections 7 which are spaced apart over the blade height H and

engage in a positively locking manner in recesses 8 arranged opposite them in the base body segment 3b, so that the two segments 3b, 3c are in a positively locking toothed engagement. The projections 7 and the recesses 8 extend over only part of the blade height. A permanent connection can be produced by a press fit or, after assembly, by soldering or welding. This arrangement may also be suitable for rotor blades, since a segment connecting surface 11 which is oriented transversely with respect to the centrifugal force is present for the mountable trailing edge segment 3c and serves as a counterpoint to the centrifugal forces acting on the trailing edge segment 3c in operation.

Fig. 2 illustrates a pinned connection between the trailing edge segment 3c and the base body segment 3b in partial section. In the base body segment 3b there are recesses 8 which lie opposite the further recesses 9 arranged in the trailing edge segment 3c, with a pin-like holding segment 10 projecting into each of them. For assembly, the holding segments 10 are inserted into the trailing edge segment 3c, for example as a press fit, and are then secured to the base body segment 3b in the same way by means of a displacement oriented transversely with respect to the blade trailing edge 5.

Fig. 3 shows a guide vane of alternative configuration for a turbine with two platforms 2a, 2b, each arranged at the end of the main blade part 3. A part of the main blade part 3 is designed as an exchangeable trailing edge segment 3c at the blade trailing edge 5. The base body segment 3b of the blade 1 has a recess 8 between two projections 7, in which the trailing edge segment 3c is entirely inserted. The projections 7 and the trailing edge segment 3c, in order for the latter to be attached and/or secured, have a pin-like holding element 10 penetrating through them in the direction of the blade trailing edge 5, which holding element can be introduced from the rear

side of the platform 2b and can then be welded to the platform 2b. As a result, the

platform 2b, in the region of the blade trailing edge 5, can merge into the base body segment 3b as projection 7, so that a complex construction can be avoided in this transition region and, by way of example, there is no need for a sealing means. Of course, a construction of this type can also be used for highly stressed blade leading edges 4 of a blade 1. Furthermore, it is possible for both blade edges 12 of the blade 1 to be simultaneously segmented in form.

Similar to figs. 1 and 2, the segmented structure of the blade leading edge 4 with respect to the main blade part 3 is illustrated in figs. 4 and 5. In this case, the connection between a leading edge segment 3a and the base body segment 3b is produced by means of toothing formed by projections 7 and recesses 8 in fig. 4 and by means of a pinned connection with pin-like holding segments 10 in fig. 5.

Dividing the blade into a number of components makes it possible to reduce the casting accuracy, which contributes to a drop in costs. Furthermore, when refurbishing the guide vane, it is possible to replace only the worn edge.

It is particularly advantageous for the segments to be formed from different materials with different strength and thermal conductivity properties, in order for the blade to be inexpensively matched to the local requirements.